

Feeds, Forage, and Fodder

A large proportion of the field crops grown in the United States are converted into meat. Feed consumed by livestock and poultry in the United States consists of about 40 percent pasture, 20 percent harvested roughage, including hay and cornstalks, and 40 percent feed concentrates, including feed grains and oilseed meal. Among the concentrates, corn accounts for 62 percent of the total, with other feed grains, including sorghum, oats, barley, wheat, and rye, accounting for 16 percent. The remaining 22 percent includes oilseed meals, animal and fish protein feeds, and mineral supplements.

Among the oilseed meals fed to livestock and poultry, soybean meal is in first place, with more than 90 percent of the market; all the rest, including cottonseed, linseed, peanut and sunflower meal, add up to less than 10 percent. The price of meals to users is based generally on relative protein content and distance from the source of the meal. Cottonseed meal, for example, costs considerably less in the Cotton Belt than it does elsewhere.

Regional research on feeds, forage, and fodders has dealt, among other things, with silage in the East, alfalfa in the West, cottonseed meal in the South, and soybean meal in the North. Chemists have also sought ways to make straw and other cellulose products digestible and to remove or inactivate substances in various feeds that impair their nutritional qualities.

Beginning in the 1940's, NRRC researchers found ways to separate soybean meal into valuable fractions, to reduce or eliminate undesirable components, and to upgrade the meal for animal feeds. At the same time, they found ways to use soy protein in human food and devised new analytical methods to determine and control the quality of soybean meal. The latter research, which was carried forward for several decades, contributed in large measure to making soybean meal first in sales and use among U.S. feed meals.



A lamb eats straw made digestible with hydrogen peroxide, sweetened with molasses, and supplemented with grains. Feeding the test animal are former NRRC biochemist J. Michael Gould, who invented the peroxide treatment, and George C. Fahey, Jr., University of Illinois scientist.

ERRC scientists, responsible for dairy research, also studied animal nutrition. Green animal fodder is made into silage by fermenting it in a silo for use in winter months when feed is scarce. Unfortunately, its nutritional content can vary widely, depending on several different factors. One measure of forage quality is the amount and type of protein in the silage. The Eastern lab developed new methods for analyzing its complex mixture of proteins, and the findings led to greatly improved and longer lasting fodder for cattle and other livestock. Scientists also learned much that was new about the mechanisms of nutrition in beef cattle.

Research began in the West in the 1970's to develop ways to convert rice straw and residues from other crops into digestible feed for livestock. The stems and leaves of crops like rice, corn, wheat, oats, and barley contain carbohydrates in the form of fibrous cellulose, but the cellulose is unavailable to livestock.

An indigestible substance called lignin glues cellulose fibers together and shields them from bacteria in the animal's digestive tract.

WRRRC scientists found several ways to make a higher percentage of rice straw digestible, including treatment with high-pressure steam and with steam plus sodium hydroxide, or household lye. Steam increased the digestibility of rice straw from 34 percent to 43 percent, and adding the lye treatment raised it to 61 percent. A few years later, straw was made even more digestible by soaking it in ammonia. Other WRRRC experiments on treating crop residues included cooperative work with several universities on corncobs, sugarcane bagasse and pineapple field trash, and seed grass straw.

A major breakthrough in residue treatment came in the 1980's, with the discovery at the Northern laboratory that hydrogen peroxide, an oxidizing agent in common use as a bleach and antiseptic, effectively dissolves the lignin in crop residue so that the digestive bacteria in livestock can reach the cellulose fibers. The oxidizing process can also facilitate the production of industrial-grade ethanol by making the cellulose more accessible to enzymes. Subsequent research showed that the lignin-free cellulose can also be used to increase the amount of fiber in human food (see "Fiber and Cholesterol," p. 107). This chain of discoveries holds promise for practical utilization of a mountain of crop wastes and residues.

Research to remove toxic or antinutritional compounds in animal and poultry feeds has been conducted at several regional laboratories. For example, SRRRC scientists worked for many years to find an economically feasible way to remove tiny pigment glands containing gossypol from cottonseed meal. Their presence made the meal toxic to poultry and hogs. Several processes were developed to reduce or eliminate gossypol, including the so-called liquid cyclone (see "Cottonseed Oil and Meal," p. 83). The resulting process is too costly for the flour to be competitive in price with soybean flour.

But soybeans also contain problem compounds. For example, certain soy components inhibit the digestive enzyme trypsin,

limiting the nutritional quality of soy products for both animals and humans. Processors routinely toast soybeans at moderately high temperatures to inactivate most of the trypsin inhibitors, allowing soy protein to be used as feed and food.

Research on the same trypsin inhibitors at the Western center has shown that the inhibitors themselves, once they are inactivated, are nutritionally valuable proteins. In addition, one of them is being evaluated for cancer-fighting properties. WRRRC scientists have developed monoclonal antibodies that can distinguish among individual inhibitors in soybeans and can be used for fast, accurate measurement of these constituents.

Soybeans also contain a class of indigestible sugars, known as raffinose oligosaccharides, that contribute to poor feed efficiency of soybean meal. These saccharides cause flatulence in animals and in humans. NRRC researchers would like to get rid of these compounds in meal, or, better yet, convert the sugars into something digestible. One research approach is to purify an enzyme, galactinol synthase, that has the potential for controlling the formation of raffinose oligosaccharides in soybeans. The purification is an essential first step in genetically engineering soybeans that do not contain these indigestible sugars.

Phytic acid is yet another antinutrient in animal feeds, affecting monogastric (one-stomach) animals like chickens and pigs. Found in grains and in soybeans and other oilseeds, it is a source of indigestible phosphorus that binds essential trace minerals and protein and lowers the nutritional value of feeds. Since phytic acid is also found in animal wastes, it eventually contributes to unwanted accumulations of phosphorus in the environment.

An enzyme, phytase, is able to break down phytic acid, eliminating its antinutritive property. It also does away with the need for additional phosphorus to be added to feeds. A research group at the Southern center has identified the enzymes responsible for synthesis of phytic acid and its breakdown in soybeans. The team intends to use this information to alter the genes of soybeans so that they will contain lower levels of phytic acid.

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